Analysis of Extreme Waves

Editorial

This special issue of **The Open Ocean Engineering Journal** aims at documenting state-of-the-art research and new advances and directions for future investigation in the area of extreme value analysis of sea waves.

Extreme Value Theory (EVT) is a branch of Statistics widely used in applied sciences since extreme events are known to play a significant role in modeling for engineering, environmental and financial purposes. In particular, the analysis of extreme wave characteristics is crucial to a variety of ocean and coastal engineering applications, such as the design of offshore platforms, wind farms, marine structures, breakwaters and other coastal works; coastal zone management; naval architecture; wave climate analysis; the estimation of the life-length and/or the failure area of an ocean-structure and more.

Stochastic modeling of sea waves extends to at least two different, yet interrelated, time scales: the short-term and the long-term. In the short-term scale, the random process of sea surface elevation is denoted by $\eta(t;\beta)$, where β is a choice variable and t is the "fast" time and is considered as stationary, Gaussian and ergodic. Since, however, in measured records of $\eta(t)$ traces of non-linearities are observed, models of non-linear character mainly based on the second-order perturbation theory have been successfully implemented. Random quantities defined on $\eta(t;\beta)$, such as the crest-to-trough wave height and the wave period, are of major interest in this time scale. These quantities could be, in principle, modeled as serially correlated sequences, but their stochastic structure is not exactly known except for some special cases. In this special issue, two papers deal with an important non-linear wave phenomenon occurring in this scale, namely rogue waves. Papadimitrakis and Dias examine the occurrence and breaking of rogue waves in deep sea waters by using a probability density function model of joint amplitudes and frequencies. They come in a more accurate determination of the limiting amplitudes that rogue waves can reach, including the influence of non-linearity of the wave field and the premature wave breaking concept. Toffoli and Bitner-Gregersen investigate the effect of wave directionality on the current design and operational criteria of marine structures. Their results conclude that when wave energy spreads on a wider range of directions the effect of modulational instability is gradually suppressed and the second order wave theory could be adequately applied to describe the statistical behavior of ocean waves.

Long-term time series of wave parameters are, in general, non-stationary with hidden or apparent periodicities, exhibiting a year-to-year statistical variability and a longer-term climatic variability. The stochastic modeling of sea waves in this case deals with the long-term process of sea surface elevation $\eta^{LT}(t;\gamma)$, where γ is a choice variable. For design purposes, a common approach is to use the sequence of spectral parameters $\vec{\Lambda}(\tau;\gamma)=\left(H_S(\tau;\gamma),\bar{T}_{02}(\tau;\gamma),\ldots\right)$ instead of $\eta^{LT}(t;\gamma)$; therefore $\eta^{LT}(t;\gamma)$ is usually treated as a piecewise stationary process. The time variable τ ranges from one to many years and for most applications only a limited number of spectral wave parameters are taken into consideration, usually the significant wave height H_S and the mean zero up-crossing period $\bar{T}_{02}$. The apparent wave characteristics defined on $\eta^{LT}(t;\gamma)$ are also of major interest in this scale; for instance, the long-term behavior of individual wave height and wave period is crucial for fatigue analysis of offshore structures' elements.

A frequent problem in the long-term extreme analysis of sea states is the lack of sufficient extreme wave data. This inconvenience can be partially overcome by using a variety of methods utilizing larger extreme-type data sets of independent values, for example, the Excesses-over-Threshold family of methods (including the Peak-Over-Threshold method, the Generalized Pareto distribution model and the point process model) and the r-largest maxima method. For all these approaches, the declustering of the available sample is an important issue, since in nature extreme values tend to appear in clusters, becoming, in this way, highly dependent. In Soukissian and Arapi, the assessment of the effect of the declustering procedures on the numerical results obtained by the r-largest model is presented. They concluded that the Run Length and DeCA approaches gave the lowest values of standard errors for the GEV distribution parameters, while the Run Length, the annual maxima method and DeCA approach provided the narrowest confidence intervals for the estimated design values of Hs. Finally, in the work of Galiatsatou and Prinos, a bivariate process of extreme sea states and storm surges is considered, by implementing a bivariate logistic model in order to extract joint exceedance probabilities of the two variables. To this end, three different parameter estimation methods were used for calculating the parameters of the margins of the bivariate distribution. Using these margins, the estimation of the failure area of a particular structure subjected to extreme sea conditions is made and the obtained results are compared.

The dynamic character of extreme value theory and its range of applications which continue to increase are exemplified by the variety of the papers included in this special issue of The Open Ocean Engineering Journal.

Finally, this special issue would not have been realized without the help and feedback of many referees, to whom I hereby extend my gratitude.

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